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(54) PROCESS CHAMBER PRESSURE CONTROL SYSTEM AND METHOD

SYSTEM UND VERFAHREN ZUR DRUCKREGELUNG BEI EINER PROZESSKAMMER

SYSTÈME ET PROCÉDÉ PERMETTANT DE RÉGULER LA PRESSION DANS UNE CHAMBRE DE TRAITEMENT

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Description

BACKGROUND OF THE INVENTION

[0001] This invention relates to the field of process chamber pressure control. More particularly the invention relates to systems for and methods of carrying out processes which involve gases in a chamber in which pressure control is needed.

[0002] Pressure control for process chambers in various fields are known. For example, in the field of ion implantation devices with a closed-loop process chamber, pressure control systems are known such as the ones disclosed in U.S. Pat. 5,672,882 to Day, et al., assigned to Advanced Micro Devices, Inc. in which fluctuations in the pressure within the process chamber are reduced by additions of appropriate amounts of inert gas when the pressure sensed by the vacuum measurement unit drops below a predetermined pressure threshold value. In these prior systems a flow control valve which may be variably opened or closed in response to an electrical control signal, and which can deliver a variable amount of flow gas, is used. In U.S. Pat. 6,152,070 to Fairbairn, et al., assigned to Applied Materials, Inc., relating to the field of chemical vapor deposition ("CVD"), a tandem process chamber is disclosed wherein pressure within a processing chamber is controlled by a slit valve as disclosed by Tepman et al. in U.S. Pat. No. 5,226,632 and by Lorimer in U.S. Pat. No. 5,363,872.

[0003] In any process chamber of the type which includes a source of gas or vapor at a higher pressure than the exhaust or outlet pressure, which includes chambers which process at positive pressure or at a negative pressure, a valve is needed to maintain pressure close to or at a selected pressure. Prior systems use a variety of valves for this purpose, among which are the aforementioned slit valves and flow control valves, and butterfly valves, proportionally closing valves, needle valves, and the like. The prior valves are relatively expensive, are bulky, and have a large footprint which makes them unsuitable in certain applications. It is an object of the present invention to provide an improved pressure control system for process chambers which include a continuous gas inflow into the chamber and a continuous gas outflow from the chamber. It is also an object to provide an improved method of controlling pressure in a process chamber which includes continuously feeding gas through an inlet to the chamber and continuously removing gas from the chamber, which is free of the disadvantages of prior systems.

[0004] US2008/0006346 describes a process for carburizing steel by alternating a carburizing period and a diffusion period. A carburizing period is where carburizing gas is supplied to a chamber and diffusion is where the carburizing gas is exhausted. The pressure in the chamber is controlled by opening and closing valves to allow the gas in and out. The exit valve operates with an adjusting valve to control the conductance to the pump when the valve is open.

[0005] US6,197,123 describes a method of cleaning a process chamber when the chamber is not being used to process semiconductor substrates.

[0006] US2007/0218203 describes an oxide film forming equipment having a reactor into which a material gas and an ozone containing gas are introduced alternately through separate valves. The exhaust gases pass from the reactor through another valve.

SUMMARY OF THE INVENTION

[0007] These objects, and others which will become apparent from the following disclosure and the drawings, are achieved by the present invention which comprises in one aspect a process chamber apparatus including a process chamber having an inlet for continuous gas inlet flow and an outlet for continuous gas outlet flow, a means for controlling process chamber pressure comprising a pressure gauge, a programmable logic controller, and a pulsed valve at, or in fluid communication with, the outlet, the pulsed valve having a controllable pulse rate, the controller being programmed to process pressure data from the pressure gauge and to vary the pulse rate of the pulsed valve as gas enters the process chamber through the inlet, based on a difference between a measured process chamber pressure and a programmed pressure, to control the process chamber pressure. The valve can be at the exit port of the chamber or anywhere in the piping connecting the chamber to the pump.

[0008] In another aspect, the invention comprises a method of controlling pressure of a process chamber included in a process chamber apparatus, having a continuous gas inlet flow and a continuous gas outlet flow comprising providing a pulsed valve at, or in fluid communication with, a gas outlet, a pressure gauge, and a programmable controller and varying the pulse rate of the pulsed valve as gas enters the process chamber through the inlet, based on a difference between a measured process chamber pressure and a programmed pressure. Either the open time or close time of the pulsed valve can be adjusted longer or shorter by the controller, depending on whether an increase or decrease in pressure within the chamber is needed to adjust pressure to programmed pressure.

[0009] In some embodiments the controller is programmed to lengthen the closed time of the pulsed valve if the gauge pressure is below a programmed pressure and to shorten the closed time of the pulsed valve if the gauge pressure is above the programmed pressure, thereby maintaining the pressure in the process chamber at or near a programmed pressure. The controller may be programmed in certain other embodiments to shorten the open time of the pulsed valve if the gauge pressure is below a programmed pressure and to lengthen the open time of the pulsed valve if the gauge pressure is above the programmed pressure, thereby maintaining the pressure in the process chamber at or near a pro-

grammed pressure.

[0010] One type of process chamber for which the invention is especially useful is for etching semiconductor wafer substrates under negative pressure wherein HF gas is introduced at an inlet and is removed after processing at an outlet. Other types of process chambers to which this invention applies are used for chemical vapor deposition on semiconductors, and plasma ion implantation. It is preferred that the pulse valve be located at the outlet of such types of process chambers to control the pressure drop between the chamber and the pump. However, any sort of apparatus which needs pressure control in a process chamber which is fed by gas or vapor at a first pressure and wherein the exhaust gas exits the chamber at an outlet at a second, lower pressure, where pressure is controlled by downstream pressure control means, can benefit from the improved pressure control system and method of this invention.

[0011] Suitable pulse valves for use in the system of the invention include Swagelok ALD-3 and ALD-6 brand valves, by way of example of commercially available pulsed valves.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] Other objects and advantages of the invention will become apparent upon reading the following detailed description and upon reference to the accompanying drawings in which:

FIG. 1 is a schematic view of an apparatus according to the invention.

DETAILED DESCRIPTION

[0013] Referring first to Fig.1, an embodiment of an apparatus according to the invention is illustrated wherein a gas source 7 feeds a combination of hydrogen fluoride gas, ethanol vapor and nitrogen gas through the inlet tube to the process chamber 6 at a relatively constant gas flow controlled by mass flow controllers (not shown) or other flow control devices.

[0014] Process chamber 6 is a corrosion resistant vacuum chamber holding silicon dioxide-containing work to be processed wherein gas is input from a gas source and is removed through an outlet, and where pressure control takes place.

[0015] Typical operating pressure for vapor HF etching is from 50 to 300 torr (from 6666 to 39997 Pa). In other fields, a wider range of pressures can be controlled by the system of the invention as long as the pressure difference at the inlet is sufficiently higher than at the output and the pump is capable, and so the invention is not limited to being used for any specific pressure.

[0016] Gas source 7 provides a constant flow of feed or process gases. In the illustrated embodiement, the inlet gas flow is typically 0.2 SLM to 4.0 SLM, but other flows, especially other higher flows, can be used in other fields and other applications of the invention. The gas is used in the illustrated embodiment in a chemical reaction in the process chamber which etches silicon dioxide and creates volatile byproducts, SiF4 and H_2O.

[0017] At the outlet from the process chamber, the exhaust, which includes the un-reacted feed products and the by-products from the chemical reaction, is withdrawn, due to negative pressure provided by pump 4 which is a vacuum pump or other device or system to generate a pressure lower than the incoming source pressure 7. The exhaust gas exits the pump 4 into a scrubber or acid compatible ventilation.

[0018] The process chamber is equipped with a pressure measurement device 2, for example a Baratron® capacitive manometer, cold cathode gauge, thermocouple gauge, or the like, which measures the pressure in the process chamber and sends pressure data to a controller 1 which is programmed to send a pulsed output 3 to pulsed valve 5, based on the difference between the measured pressure value and the desired or inputted pressure value, thereby controlling the rate at which the valve is pulsed.

[0019] Pulsed Valve 5 is any valve capable of receiving a pulsed signal from the controller 1 which can stop or allow gas flow between process chamber 6 and pump 4.

[0020] The pulsed output 3 can be mechanical, electromechanical, electrical, pneumatic, or any method which causes the valve to switch between its open to closed state at a controlled rate. The rate, of course, is varied, depending on whether the actual pressure is above or below the setpoint.

[0021] In some embodiments of the invention, controller 1 is programmed to lengthen the closed time of pulsed valve 5 if gauge pressure measurement device 2 indicates a pressure below a programmed pressure and to shorten the closed time of pulsed valve 5 if the gauge pressure measurement device 2 indicates a pressure above the programmed pressure, thereby maintaining the pressure in the process chamber 6 at or near a programmed pressure.

[0022] In some other embodiments controller 1 is programmed to shorten the open time of the pulsed valve 5 if the gauge pressure measurement device 2 indicates a pressure below a programmed pressure and to lengthen the open time of pulsed valve 5 if the gauge pressure is above the programmed pressure, thereby maintaining the pressure in the process chamber 6 at or near a programmed pressure.

[0023] Alternatively, controller 1 can be programmed to adjust both the open and closed timings of pulsed valveS to provide less average conductance between the process chamber 6 and the pump 4 if the gauge pressure is below a programmed pressure and to adjust both the open and closed timings of the pulsed valve to provide more average conductance between the process chamber and the pump 4 if the gauge pressure is above a programmed pressure.

[0024] The present invention, therefore, is well adapted to carry out the objects and attain the ends and ad-

vantages mentioned, as well as others inherent therein. While the invention has been depicted and described and is defined by reference to particular preferred embodiments of the invention, such references do not imply a limitation on the invention, and no such limitation is to be inferred. The invention is defined by the appended claims.

Claims

1. A process chamber apparatus including a process chamber (6) having an inlet for continuous gas inlet flow and an outlet for continuous gas outlet flow, a means for controlling process chamber pressure comprising a pressure gauge (2), a programmable logic controller (1), and a pulsed valve (5) at, or in fluid communication with, the outlet, the pulsed valve (5) having a controllable pulse rate, the controller (1) programmed to process pressure data from the pressure gauge (2) and to vary the pulse rate of the pulsed valve (5) **characterised in that**, the pulsed valve (5) is configured in a such manner that the pulse rate of said pulsed valve (5) is varied as gas enters the process chamber (6) through the inlet, based on a difference between a measured process chamber pressure and a programmed pressure, to control the process chamber pressure.

2. The apparatus of claim 1 wherein the controller (1) is programmed to lengthen the closed time of the pulsed valve (5) if the gauge pressure is below a programmed pressure and to shorten the closed time of the pulsed valve (5) if the gauge pressure is above the programmed pressure, thereby maintaining the pressure in the process chamber (6) at or near a programmed pressure.

3. The apparatus of claim 1 wherein the controller (1) is programmed to shorten the open time of the pulsed valve (5) if the gauge pressure is below a programmed pressure and to lengthen the open time of the pulsed valve (5) if the gauge pressure is above the programmed pressure, thereby maintaining the pressure in the process chamber (6) at or near a programmed pressure.

4. The apparatus of claim 1 wherein the controller (1) is programmed to adjust both the open and closed timings of the pulsed valve (5) to provide less average conductance between the process chamber (6) and the pump (4) if the gauge pressure is below a programmed pressure and to adjust both the open and closed timings of the pulsed valve (5) to provide more average conductance between the process chamber (6) and the pump (4) if the gauge pressure is above a programmed pressure.

5. The apparatus of claim 1 wherein the gas is HF, ethanol vapor and nitrogen and the process chamber is adapted to etch semiconductor wafers.

6. The apparatus of claim 1 wherein the pressure guage (2) is selected from a capacitive manometer, a cold cathode gauge, and a thermocouple gauge.

7. The apparatus of claim 1 wherein the apparatus is adapted to maintain the pressure at a value within the range of about 50 to 300 Torr (about 6666 to 39997 Pa).

8. The apparatus of claim 1 wherein the apparatus is adapted to maintain the inlet gas flow at a level of about 0.2 to 4.0 SLM.

9. A method of controlling pressure of a process chamber (6) included in a process chamber apparatus (6), having a continuous gas inlet flow and a continuous gas outlet flow comprising providing a pulsed valve (5) at a gas outlet, a pressure gauge (2), and a programmable logic controller (1) the method being **characterised in that** the pulse rate of the pulsed valve is varied as gas enters the process chamber through the inlet, based on a difference between a measured process chamber pressure and a programmed pressure.

10. The method of claim 9 comprising programming the controller (1) to lengthen the closed time of the pulsed valve (5) if the gauge pressure is below a programmed pressure and to shorten the closed time of the pulsed valve (5) if the gauge pressure is above the programmed pressure, thereby maintaining the pressure in the process chamber (6) at or near a programmed pressure.

11. The method of claim 9 comprising programming the controller (1) to shorten the open time of the pulsed valve (5) if the gauge pressure is below a programmed pressure and to lengthen the open time of the pulsed valve (5) if the gauge pressure is above the programmed pressure, thereby maintaining the pressure in the process chamber (6) at or near a programmed pressure.

12. The method of claim 9 comprising programming the controller (1) to adjust both the open and closed timings of the pulsed valve (5) to provide less average conductance between the process chamber (6) and the pump (4) if the gauge pressure is below a programmed pressure and to adjust both the open and closed timings of the pulsed valve (5) to provide more average conductance between the process chamber (6) and the pump (4) if the gauge pressure is above a programmed pressure.

13. The method of claim 9 wherein the gas is HF, ethanol vapor and nitrogen and the process chamber (6) is adapted to etch semiconductor wafers.

14. The method of claim 9 comprising maintaining pressure at a value within the range of about 50 to 300 Torr (about 6666 to 39997 Pa).

15. The method of claim 9 comprising maintaining the inlet gas flow at a level of about 0.2 to 4.0 SLM.

Patentansprüche

1. Prozesskammervorrichtung, die Folgendes umfasst: eine Prozesskammer (6) mit einem Einlass für einen kontinuierlichen Gaseinlauf und einem Auslass für einen kontinuierlichen Gasauslauf, ein Mittel zum Regeln von Prozesskammerdruck, umfassend ein Druckmessgerät (2), eine programmierbare Logiksteuerung (1) und ein gepulstes Ventil (5) an oder in Fluidverbindung mit dem Auslass, wobei das gepulste Ventil (5) eine regelbare Pulsrate hat, wobei die Steuerung (1) zum Verarbeiten von Druckdaten von dem Druckmessgerät (2) und zum Variieren der Pulsrate des gepulsten Ventils (5) programmiert ist, **dadurch gekennzeichnet, dass** das gepulste Ventil (5) so konfiguriert ist, dass die Pulsrate des genannten gepulsten Ventils (5) auf der Basis einer Differenz zwischen einem gemessenen Prozesskammerdruck und einem programmierten Druck variiert wird, während Gas durch den Einlass in die Prozesskammer eintritt, um den Prozesskammerdruck zu regeln.

2. Vorrichtung nach Anspruch 1, wobei die Steuerung (1) zum Verlängern der Schließzeit des gepulsten Ventils (5) programmiert ist, wenn der Messgerätdruck unter einem programmierten Wert liegt, und zum Verkürzen der Schließzeit des gepulsten Ventils (5), wenn der Messgerätdruck über dem programmierten Wert liegt, um dadurch den Druck in der Prozesskammer (6) auf oder nahe einem programmierten Wert zu halten.

3. Vorrichtung nach Anspruch 1, wobei die Steuerung (1) zum Verkürzen der Öffnungszeit des gepulsten Ventils (5) programmiert ist, wenn der Messgerätdruck unter einem programmierten Wert liegt, und zum Verlängern der Öffnungszeit des gepulsten Ventils (5), wenn der Messgerätdruck über dem programmierten Wert liegt, um dadurch den Druck in der Prozesskammer (6) auf oder nahe einem programmierten Wert zu halten.

4. Vorrichtung nach Anspruch 1, wobei die Steuerung (1) zum Justieren der Öffnungs- und Schließzeiten des gepulsten Ventils (5) programmiert ist, um weniger durchschnittliche Leitfähigkeit zwischen der Prozesskammer (6) und der Pumpe (4) zu erzielen, wenn der Messgerätdruck unter einem programmierten Wert liegt, und um die Öffnungs- und Schließzeiten des gepulsten Ventils (5) zu justieren, um mehr durchschnittliche Leitfähigkeit zwischen der Prozesskammer (6) und der Pumpe (4) zu erzielen, wenn der Messgerätdruck über einem programmierten Wert liegt.

5. Vorrichtung nach Anspruch 1, wobei das Gas HF, Ethanoldampf und Stickstoff ist und die Prozesskammer zum Ätzen von Halbleiterwafern ausgelegt ist.

6. Vorrichtung nach Anspruch 1, wobei das Druckmessgerät (2) aus einem kapazitiven Manometer, einem Kaltkathodenmessgerät und einem Thermoelementmessgerät ausgewählt ist.

7. Vorrichtung nach Anspruch 1, wobei die Vorrichtung zum Halten des Drucks auf einem Wert im Bereich von etwa 50 bis 300 Torr (etwa 6666 bis 39.997 Pa) ausgelegt ist.

8. Vorrichtung nach Anspruch 1, wobei die Vorrichtung zum Halten des Einlassgasflusses auf einem Niveau von etwa 0,2 bis 4,0 SLM ausgelegt ist.

9. Verfahren zum Regeln eines Drucks einer Prozesskammer (6), die in einer Prozesskammervorrichtung (6) enthalten ist, mit einem kontinuierlichen Gaseinlauf und einem kontinuierlichen Gasauslauf, das das Bereitstellen eines gepulsten Ventils (5) an einem Gasauslass, eines Druckmessgeräts (2) und einer programmierbaren Logiksteuerung (1) beinhaltet, wobei das Verfahren **dadurch gekennzeichnet ist, dass** die Pulsrate des gepulsten Ventils auf der Basis einer Differenz zwischen einem gemessenen Prozesskammerdruck und einem programmierten Druck variiert wird, während Gas durch den Einlass in die Prozesskammer eintritt.

10. Verfahren nach Anspruch 9, das das Programmieren der Steuerung (1) beinhaltet, um die Schließzeit des gepulsten Ventils (5) zu verlängern, wenn der Messgerätdruck unter einem programmierten Wert liegt, und um die Schließzeit des gepulsten Ventils (5) zu verkürzen, wenn der Messgerätdruck über dem programmierten Wert liegt, um dadurch den Druck in der Prozesskammer (6) auf oder nahe einem programmierten Wert zu halten.

11. Verfahren nach Anspruch 9, das das Programmieren der Steuerung (1) beinhaltet, um die Öffnungszeit des gepulsten Ventils (5) zu verkürzen, wenn der Messgerätdruck unter einem programmierten Wert liegt, und um die Öffnungszeit des gepulsten

Ventils (5) zu verlängern, wenn der Messgerätdruck über dem programmierten Wert liegt, um dadurch den Druck in der Prozesskammer (6) auf oder nahe einem programmierten Wert zu halten.

12. Verfahren nach Anspruch 9, das das Programmieren der Steuerung (1) beinhaltet, um die Öffnungs- und Schließzeiten des gepulsten Ventils (5) zu justieren, um weniger durchschnittliche Leitfähigkeit zwischen der Prozesskammer (6) und der Pumpe (4) zu erzielen, wenn der Messgerätdruck unter einem programmierten Wert liegt, und um die Öffnungs- und Schließzeiten des gepulsten Ventils (5) zu justieren, um mehr durchschnittliche Leitfähigkeit zwischen der Prozesskammer (6) und der Pumpe (4) zu erzielen, wenn der Messgerätdruck über einem programmierten Wert liegt.

13. Verfahren nach Anspruch 9, wobei das Gas HF, Ethanoldampf und Stickstoff ist und die Prozesskammer (6) zum Ätzen von Halbleiterwafern ausgelegt ist.

14. Verfahren nach Anspruch 9, das das Halten von Druck auf einem Wert im Bereich von etwa 50 bis 300 Torr (etwa 6666 bis 39.997 Pa) beinhaltet.

15. Verfahren nach Anspruch 9, das das Halten des Einlassgasflusses auf einem Niveau von etwa 0,2 bis 4,0 SLM beinhaltet.

Revendications

1. Appareil à chambre de traitement comprenant une chambre de traitement (6) ayant une entrée pour un écoulement gazeux continu d'entrée et une sortie pour un écoulement gazeux continu de sortie, un moyen permettant de réguler une pression de chambre de traitement et comprenant une jauge de pression (2), un contrôleur logique programmable (1) et une vanne pulsatoire (5) au niveau de la sortie ou en communication fluidique avec celle-ci, la vanne pulsatoire (5) ayant une fréquence d'impulsions régulable, le contrôleur (1) étant programmé pour traiter des données de pression en provenance du manomètre (2) et pour faire varier la fréquence d'impulsions de la vanne pulsatoire (5),
l'appareil étant **caractérisé en ce que** la vanne pulsatoire (5) est configurée de sorte que la fréquence d'impulsions de ladite vanne pulsatoire (5) varie quand un gaz entre dans la chambre de traitement (6) par l'entrée, sur la base d'une différence entre une pression de chambre de traitement mesurée et une pression programmée, pour réguler la pression de chambre de traitement.

2. Appareil selon la revendication 1, dans lequel le contrôleur (1) est programmé pour allonger le temps de fermeture de la vanne pulsatoire (5) si la pression manométrique est inférieure à une pression programmée et pour raccourcir le temps de fermeture de la vanne pulsatoire (5) si la pression manométrique est supérieure à la pression programmée, de manière à maintenir la pression dans la chambre de traitement (6) égale à une pression programmée ou voisine de celle-ci.

3. Appareil selon la revendication 1, dans lequel le contrôleur (1) est programmé pour raccourcir le temps d'ouverture de la vanne pulsatoire (5) si la pression manométrique est inférieure à une pression programmée et pour allonger le temps d'ouverture de la vanne pulsatoire (5) si la pression manométrique est supérieure à la pression programmée, de manière à maintenir la pression dans la chambre de traitement (6) égale à une pression programmée ou voisine de celle-ci.

4. Appareil selon la revendication 1, dans lequel le contrôleur (1) est programmé pour régler le temps d'ouverture et le temps de fermeture de la vanne pulsatoire (5) pour fournir une conductance moyenne moindre entre la chambre de traitement (6) et la pompe (4) si la pression manométrique est inférieure à une pression programmée et pour régler le temps d'ouverture et le temps de fermeture de la vanne pulsatoire (5) pour fournir une conductance moyenne plus élevée entre la chambre de traitement (6) et la pompe (4) si la pression manométrique est supérieure à une pression programmée.

5. Appareil selon la revendication 1, dans lequel le gaz est du HF, de la valeur d'éthanol et de l'azote et la chambre de traitement est conçue pour graver des tranches de semiconducteur.

6. Appareil selon la revendication 1, dans lequel la jauge de pression (2) est sélectionnée parmi un manomètre capacitif, une jauge à cathode froide et une jauge à thermocouple.

7. Appareil selon la revendication 1, l'appareil étant conçu pour maintenir la pression à une valeur de l'ordre d'environ 50 à 300 Torr (environ 6666 à 39997 Pa).

8. Appareil selon la revendication 1, l'appareil étant conçu pour maintenir l'écoulement gazeux d'entrée à un niveau d'environ 0,2 à 4,0 SLM.

9. Procédé de régulation de la pression d'une chambre de traitement (6) comprise dans un appareil de chambre de traitement (6), ayant un écoulement gazeux continu d'entrée et un écoulement gazeux continu de sortie, consistant à fournir une vanne pulsa-

toire (5) au niveau d'une sortie de gaz, une jauge de pression (2) et un contrôleur logique programmable (1), le procédé étant **caractérisé en ce que** la fréquence d'impulsions de la vanne pulsatoire varie quand un gaz entre dans la chambre de traitement par l'entrée, sur la base d'une différence entre une pression de chambre de traitement mesurée et une pression programmée.

10. Procédé selon la revendication 9, consistant à programmer le contrôleur (1) pour allonger le temps de fermeture de la vanne pulsatoire (5) si la pression manométrique est inférieure à une pression programmée et pour raccourcir le temps de fermeture de la vanne pulsatoire (5) si la pression manométrique est supérieure à la pression programmée, de manière à maintenir la pression dans la chambre de traitement (6) égale à une pression programmée ou voisine de celle-ci.

11. Procédé selon la revendication 9, consistant à programmer le contrôleur (1) pour raccourcir le temps d'ouverture de la vanne pulsatoire (5) si la pression manométrique est inférieure à une pression programmée et pour allonger le temps d'ouverture de la vanne pulsatoire (5) si la pression manométrique est supérieure à la pression programmée, de manière à maintenir la pression dans la chambre de traitement (6) égale à une pression programmée ou voisine de celle-ci.

12. Procédé selon la revendication 9, consistant à programmer le contrôleur (1) pour régler le temps d'ouverture et le temps de fermeture de la vanne pulsatoire (5) pour fournir une conductance moyenne moindre entre la chambre de traitement (6) et la pompe (4) si la pression manométrique est inférieure à une pression programmée et pour régler le temps d'ouverture et le temps de fermeture de la vanne pulsatoire (5) pour fournir une conductance moyenne plus élevée entre la chambre de traitement (6) et la pompe (4) si la pression manométrique est supérieure à une pression programmée.

13. Procédé selon la revendication 9, dans lequel le gaz est du HF, de la valeur d'éthanol et de l'azote et la chambre de traitement (6) est conçue pour graver des tranches de semiconducteur.

14. Procédé selon la revendication 9, consistant à maintenir une pression à une valeur de l'ordre d'environ 50 à 300 Torr (environ 6666 à 39997 Pa).

15. Procédé selon la revendication 9, consistant à maintenir l'écoulement gazeux d'entrée à un niveau d'environ 0,2 à 4,0 SLM.

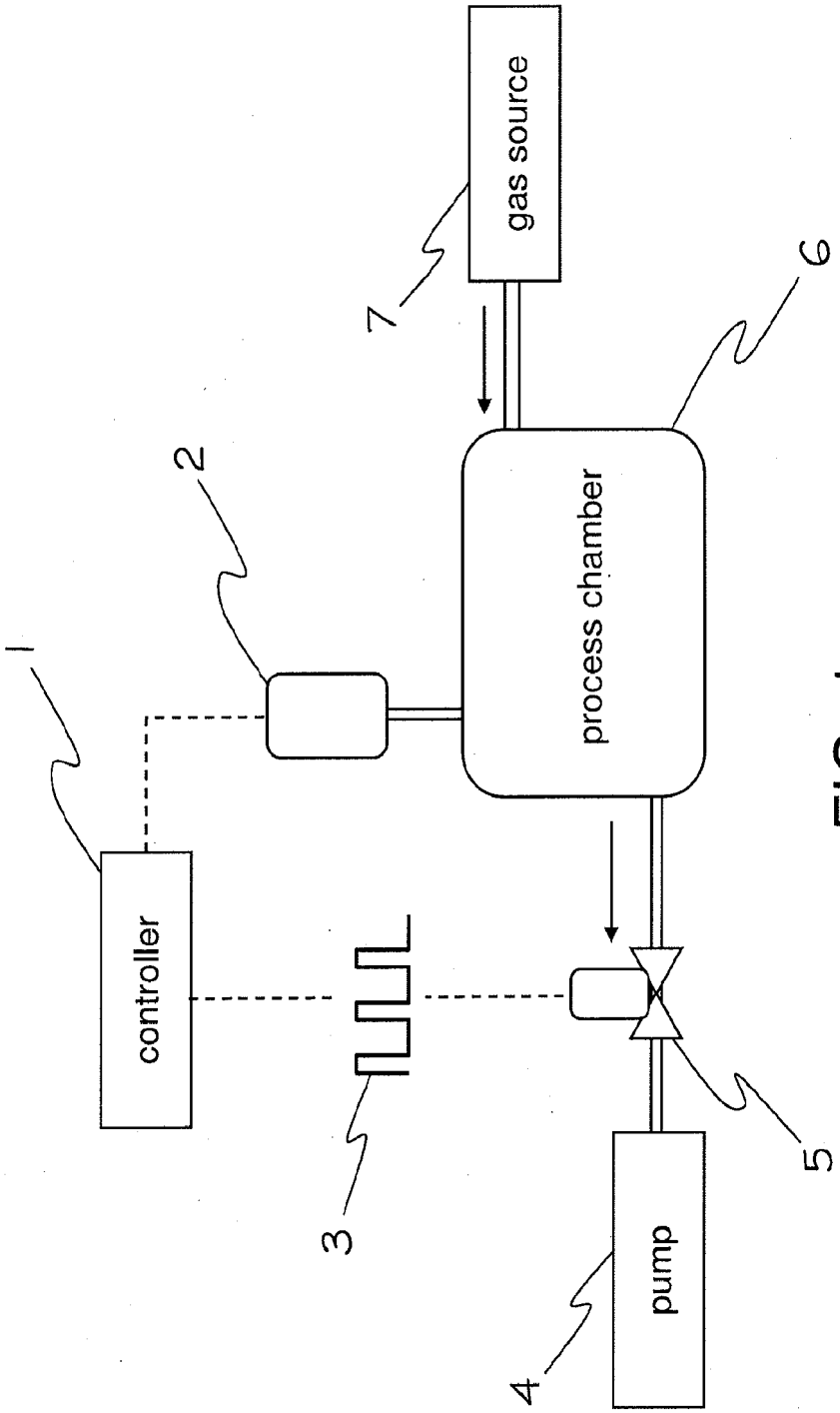

FIG. 1

REFERENCES CITED IN THE DESCRIPTION

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